Draft Report: Wind & Non-Wind Energy Renewable DG Technology Review

Presentation to:

Cape Light Compact and Cape Cod Commission
MTC Model Bylaw Working Group Meeting

by:

Boreal Renewable Energy Development
& Serchuk Associates

February 27, 2004

Presentation Overview

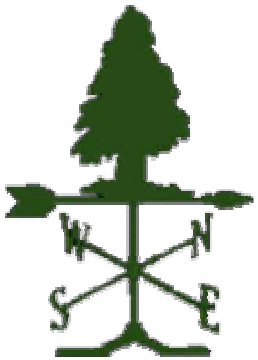
- Introductions
  - Project Goals
    - Scope of Wind Technology Review
    - Scope Non-wind Technology Review
- Non-Wind Findings
- Wind Findings
  - Siting & Permitting Analysis
  - Wind Resource, Wind Turbine and Tower Analysis
  - Modeling Assumptions & Results
  - Recommendations & Discussion

Goals

- To provide analysis that will help inform the development of model bylaws for renewable DG for Cape Cod and Martha's Vineyard
  - Generally, what will be the effect of zoning restrictions on DG development?
  - Most importantly, what will be the effect of height and other restriction on DG wind development?
- Understanding of Group Goals: Crafted bylaws will not be a *de facto* prohibition of wind turbines.

Study Inputs / Tools

- Publicly Available Information:
  - Wind & non-wind technology and offerings
  - Siting criteria / permitting
- Interviews with US and European Planning Experts
- Wind Turbine Manufacturer Technology Survey (Custom for Study)
  - Publicly available
  - Responses to survey
- Wind DG Project Sensitivity Analysis Spreadsheet Tool
  - Proprietary tool of Boreal Renewable Energy Development



Fully Participating Manufacturers

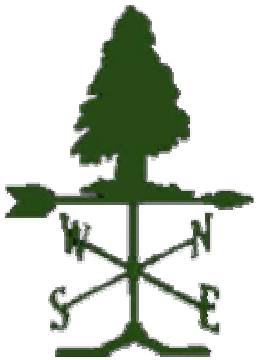
Manufacturer	Largest kW Turbine
Southwest	1 kW
Bergey	10 kW
WTI	12 kW
AOC	50 kW
Northern Power	100 kW
Fuhrlander	1000 kW
Gamesa	1800 kW

- Other respondents: Bonus Energy, Enercon, GE, NEG Micon, Mitsubishi, Specialized Power Sytems, Suzlon, Vestas

Non-Wind Analysis

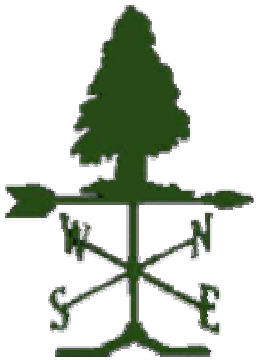
Microturbine Overview

- Small, clean gas turbines
  - Natural gas, renewable fuels, other
  - NG-fueled: $1576/kW - $2636/kW installed
- Industry struggling and unstable
  - Moving to larger products (~200 kW)
  - Exploiting "opportunity fuels"
  - Integrated combined-heat-and-power packages
- Specifications for 7 MT models
  - Capstone, Ingersoll-Rand, Elliott, Bowman



Fuel Cell Overview

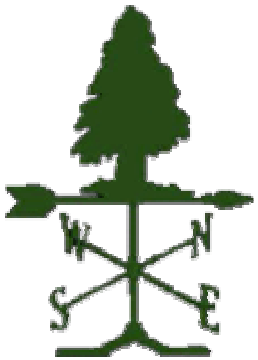
- Generate power chemically, w/o combustion
  - Natural gas, methanol, renewable fuels, other
  - NG-fueled: $3250/kW – $5500/kW installed
- Very few commercial products
  - Only one FC with appreciable operating experience
  - New product: small, direct-hydrogen FCs for back-up power
- Specifications for 6 FC products
  - UTC Fuel Cells, Fuel Cell Energy, Ballard, Avista, Plug Power



Photovoltaic Overview

- Convert sunlight to electricity
  - 20 – 30 cents/kWh or much more, depending on regulations, financing, weather, etc.
  - Rarely cost-effective except in off-grid applications
- Wide variety of products
  - A la carte solar panels
  - Packaged systems: panel, inverter, wiring, etc.
  - Building-integrated: facades, shingles, etc.
- Specifications for 9 PV products
  - RWE Schott, Evergreen, BP Solar, Sharp, PowerLight, Kyocera, Astropower, United Solar

Wind Analysis



Wind Conclusions / Recommendations

- A height restriction of 200 feet would be a *de facto* denial of economically feasible siting of wind turbines in all but the most unusual cases.
  - We recommend either 400 foot or no *a priori* height restriction on turbines in appropriate districts (e.g., commercial and industrial parks). A restriction of 200 feet height is most likely appropriate for residential zones.

Siting / Permitting Analysis

Siting Criteria

- Finding a balance between wind turbine development and the unique characteristics of Cape Cod and Martha's Vineyard
  - Policy/unregulated aspects
    - Avian impacts
    - Visibility impacts
  - Regulated Aspects
    - FAA
    - FCC
    - NPDES
    - Wetlands
    - Noise
    - Rare & Endangered Species
    - Archeological /Historic Preservation

Avian Studies

- Advances in technology have improved survivability from bird/wind turbine interaction
  - Larger turbines
    - more visible blades
    - Fewer turbines/given area
  - Tubular towers vs. lattice
  - Slower rotational speed
- Avian studies are recommended on a site specific basis
- Also note: Mass Audubon's recent purchase of green energy which includes 10% wind

Visual Impact

- Studies have shown number of turbines have a greater adverse public reaction versus height on the viewshed
- Many tools available for visual impact studies:
  - Geographic analysis
  - Photographic modeling
  - 3D computer modeling
  - Use internet for community access to studies
- Visual impact studies are recommended on a site specific basis depending on the scale and potential visual impact of a given project

FAA / FCC

- FAA
  - Obstruction permitting – for both turbine and construction crane
  - Lighting marking requirements
    - Additional lighting requirements are prompted from increases in tower height
      - Have the potential of increasing adverse impacts to the scenic resources of Cape Cod and Martha's Vineyard and potential avian impacts (e.g. high powered strobes)
    - New policy being developed
- FCC
  - Licensing required for telemetry system (if any)
  - Consider interference via proximity to existing transmission towers

Stormwater / Wetlands / Coastal Zones

- Stormwater Control
  - NPDES permit required if > than 1 acre of impact from temporary roads
- Wetlands
  - Upland areas should be developed prior to placement in wetland areas
    - Exceptional resource on Cape
    - Non-advantageous foundation soils
    - Low lying areas – less wind potential
    - Greater potential rare/endangered species impact
    - Other issues
- Coastal Zones
  - There may be highly desirable locations in coastal zones that would be economic and minimize adverse impacts, such as on developed breakwaters

Noise – MA Regulation *310 CMR 7.09-7.10*

- *A noise source will be considered to be violating the Department's noise regulation (310 CMR 7.10) if the source:*
  - Increases the broadband sound level by more than 10 dB(A) above ambient, or
  - Produce a "pure tone" condition – when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.
  - These criteria are measured both at the property line and at the nearest inhabited residence

Noise - Continued

- Noise impact surveys are not recommended based on manufacturer supplied data of relatively low noise impact at 500 feet
  - Manufacturer noise information must be supplied to determine compliance with Massachusetts state noise policy including tonal noise
- Qualified acoustic engineers should be involved on a site specific basis in confirming aspects of the noise environment and predicted impacts if sensitive resources or receptors are identified prior to development

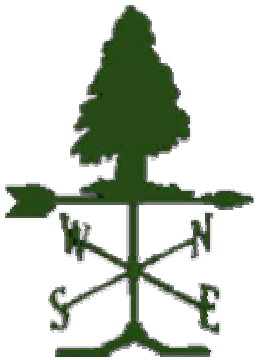
Rare & Endangered Impact Historic / Archeological Impacts

- Minimize footprint and temporary road construction impacts wherever possible
- Perform notifications to Natural Heritage programs and Fish & Wildlife Service
- Involve Massachusetts Historical Commission and archeologist where appropriate

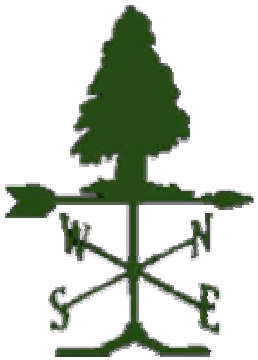
Zoning

- The minimum set back of a turbine system should be associated with its fall zone and noise impacts, not an arbitrary minimum acreage. Setbacks should not include public ways. Developers of turbines should have the opportunity to purchase easements from setback requirements from adjoining property.

- Designate sensitive and or scenic resource overlay districts (such as National Monuments and Recreation areas, State parks, wildlife refuges, historic, archeological sites) on zoning maps requiring mandatory visual impact analysis review if there is proposed development in these areas.



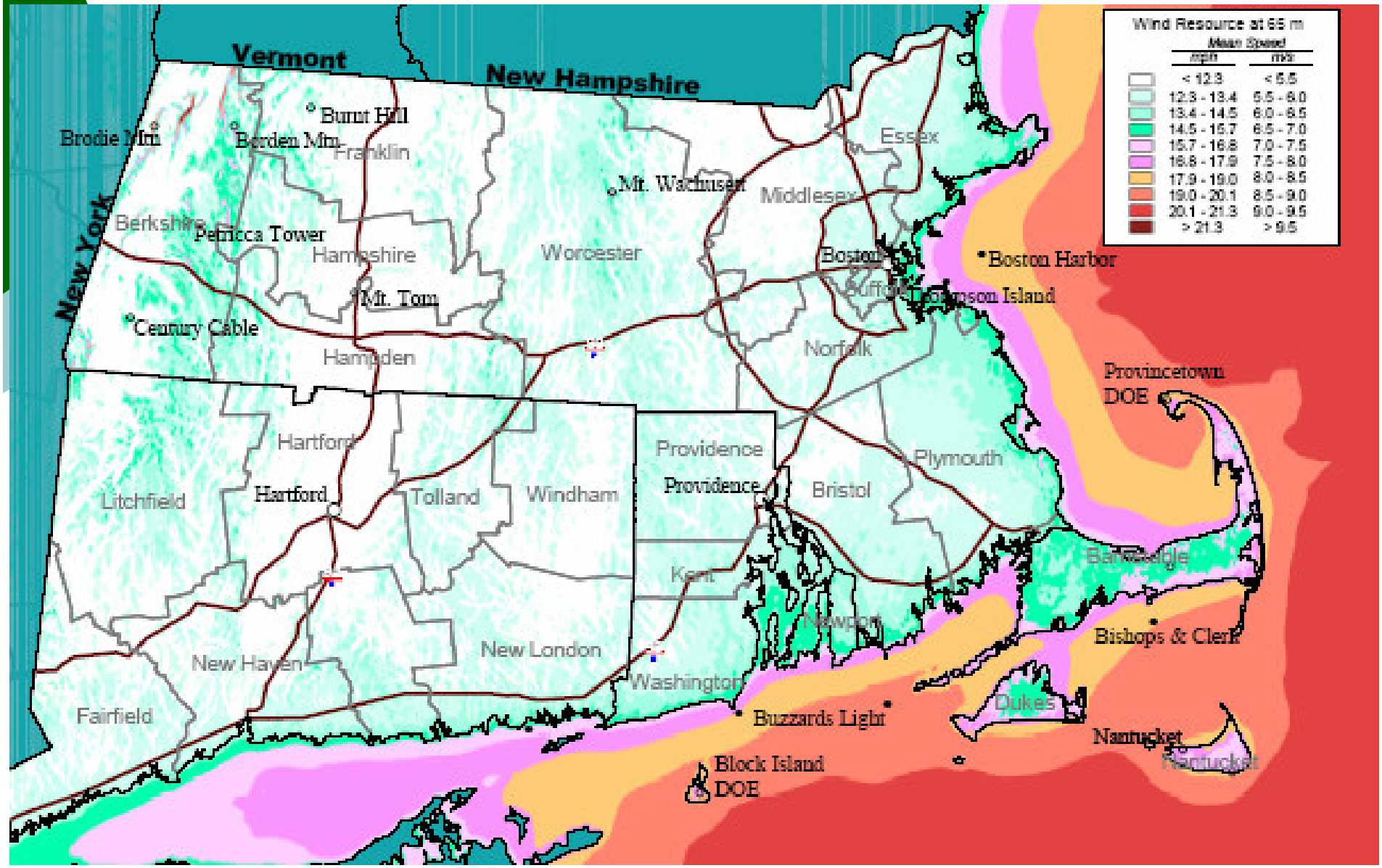
Wind Resources, Wind Turbines & Towers



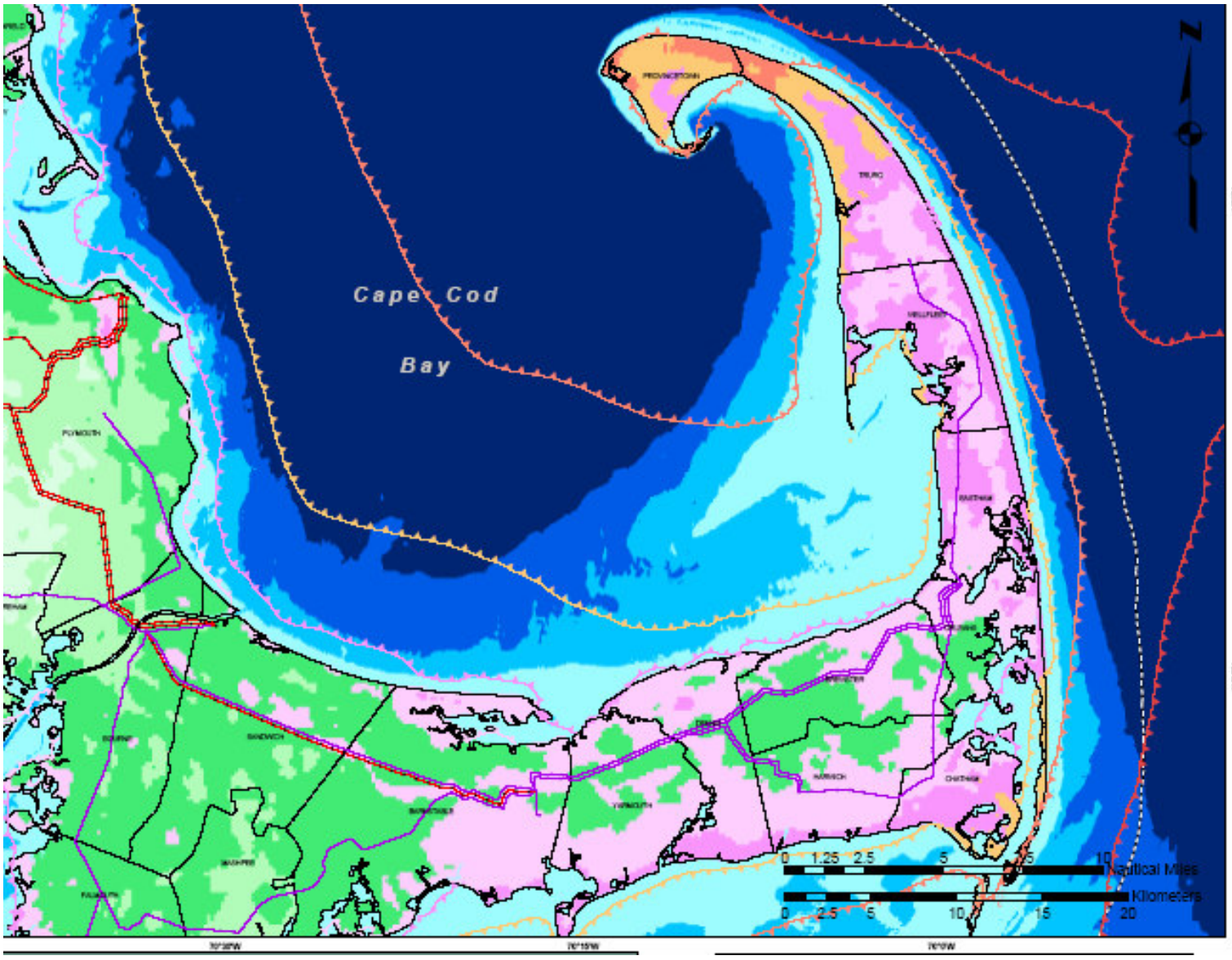
Wind Power – Real Quick

- The (theoretical) energy in the wind is a function of:
  - The density of the air
    - Related to altitude, temperature, and weather conditions (e.g., high pressure vs. low pressure)
  - The area swept by the turbine blade
    - Meaning power is a function of the square of the rotor radius
  - The cube of wind speed.
    - Generally the higher above ground level, the faster the wind speed (wind shear)

Southern NE Wind Resources



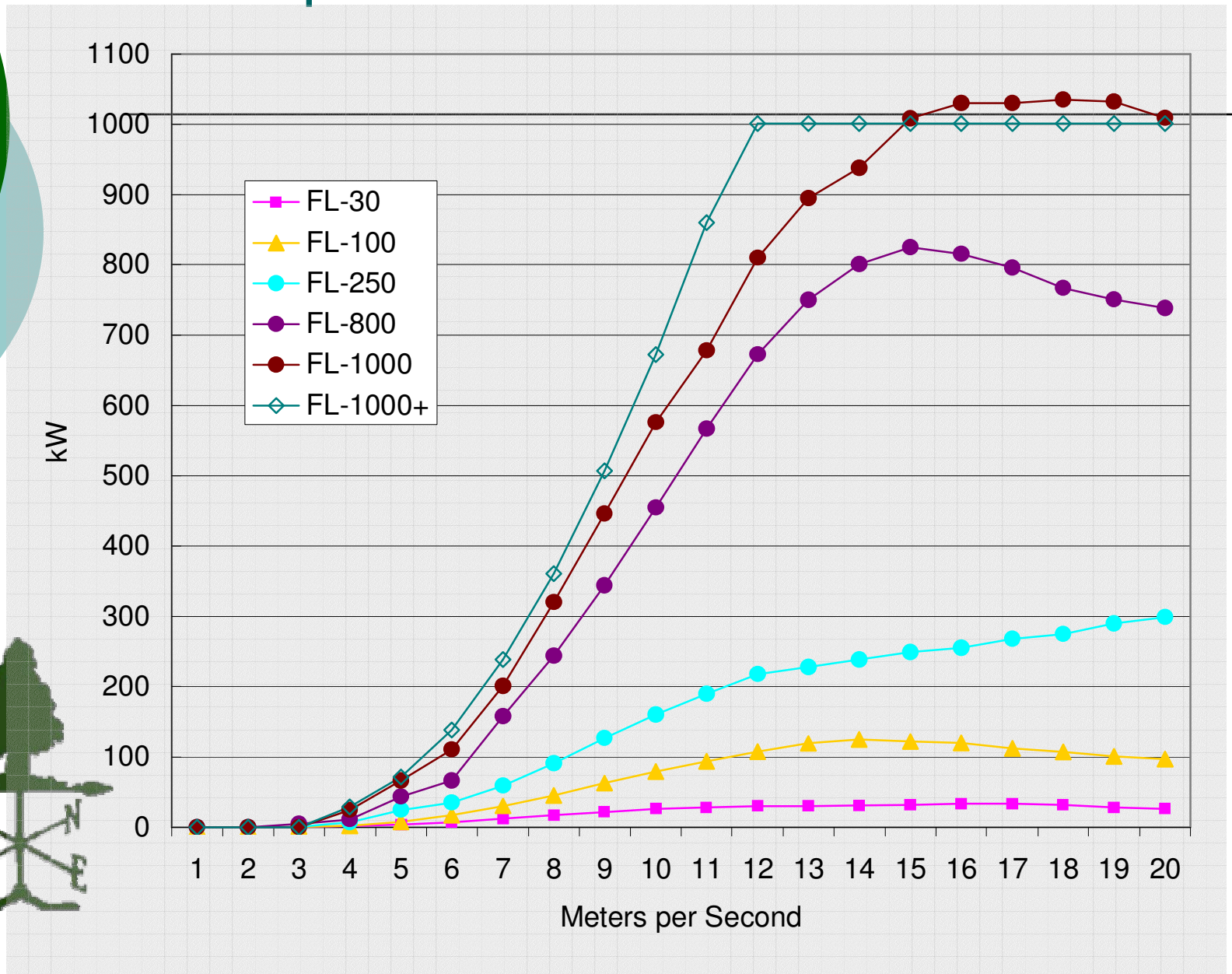
(Most of) Cape Cod Wind Resources



Wind Power – Real Quick II

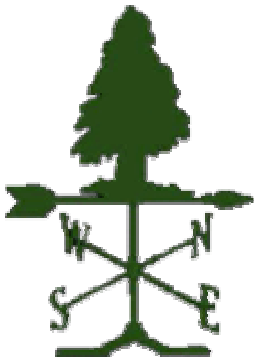
- Turbines do not extract the theoretical maximum energy from the wind
  - The industry provides power curves, which show the amount of power that a given turbine can produce for a given wind speed (making certain assumptions – e.g., air density, temperature, wind shear)

Example Power Curves - Fuhrlander



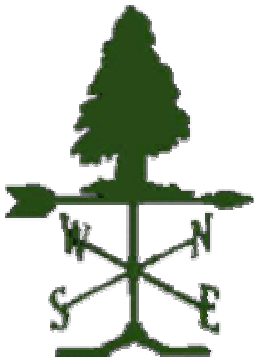
Utility Charges – Real Quick

- Charged on Various Units of Consumption
  - Monthly Customer
  - Peak demand (kW)
  - Energy consumption (kWh)
  - Other (e.g., metering, interconnection study)
- For Different Types of services
  - Generation (either utility or competitive)
  - Distribution
  - Transmission
  - Transition (i.e., stranded costs)
  - Energy Efficiency / Renewable Fund



Turbine “Revenue”

- Avoiding Utility Charges (can only avoid kWh, not kW or monthly customer charge)
  - Generation (either utility or competitive)
  - Distribution
  - Transmission
  - Transition
  - Energy Efficiency / Renewable Fund
- Sales to Wholesale Market
- RECs (Renewable Energy Credits)

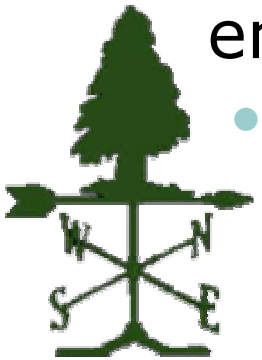


Other Turbine Financial Advantages

- Taxes
  - Very aggressive depreciation (MACRS)
  - No sales tax
  - Up to $1000 personal state tax credit
  - Potential Federal PTC (Production Tax Credit)
    - Less important for most DG applications
- Dampens Price Volatility
- Potential Additional Environmental Offset Sales
- MTC Grant Programs

Other Considerations

- Significant benefits to air quality (based on 15 MW installed wind)
- Best current solution to mitigation of GHG emissions
  - Avian impacts more threatened by rising sea level vs. wind turbines?

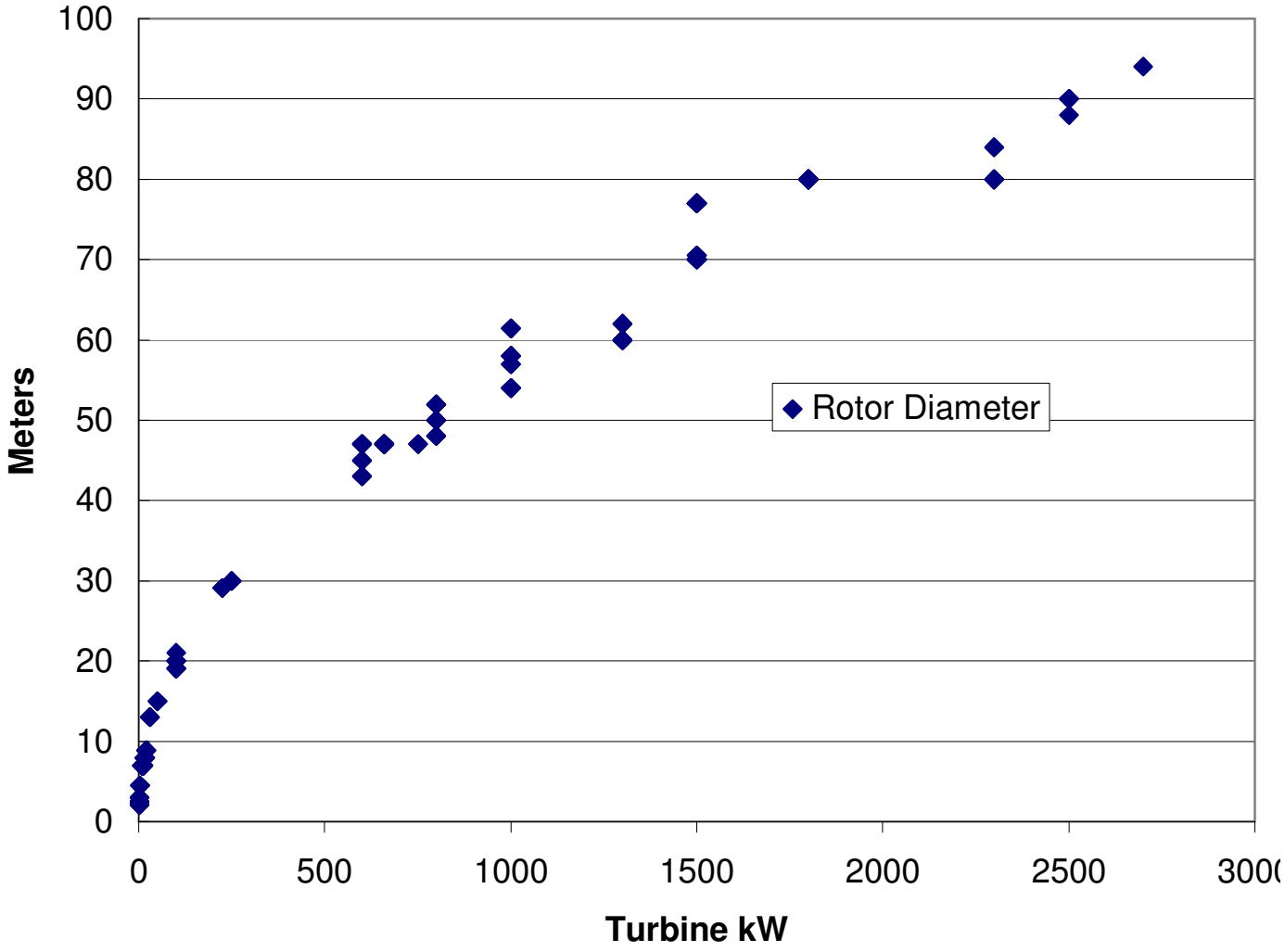


Pollutant	Annual Average Emission Rate (lb/MWh)	Potential Annual Avoided Emissions (ton/yr)
SO_2	3.27	57
NOx	1.12	19
CO_2	1337.8	23,116

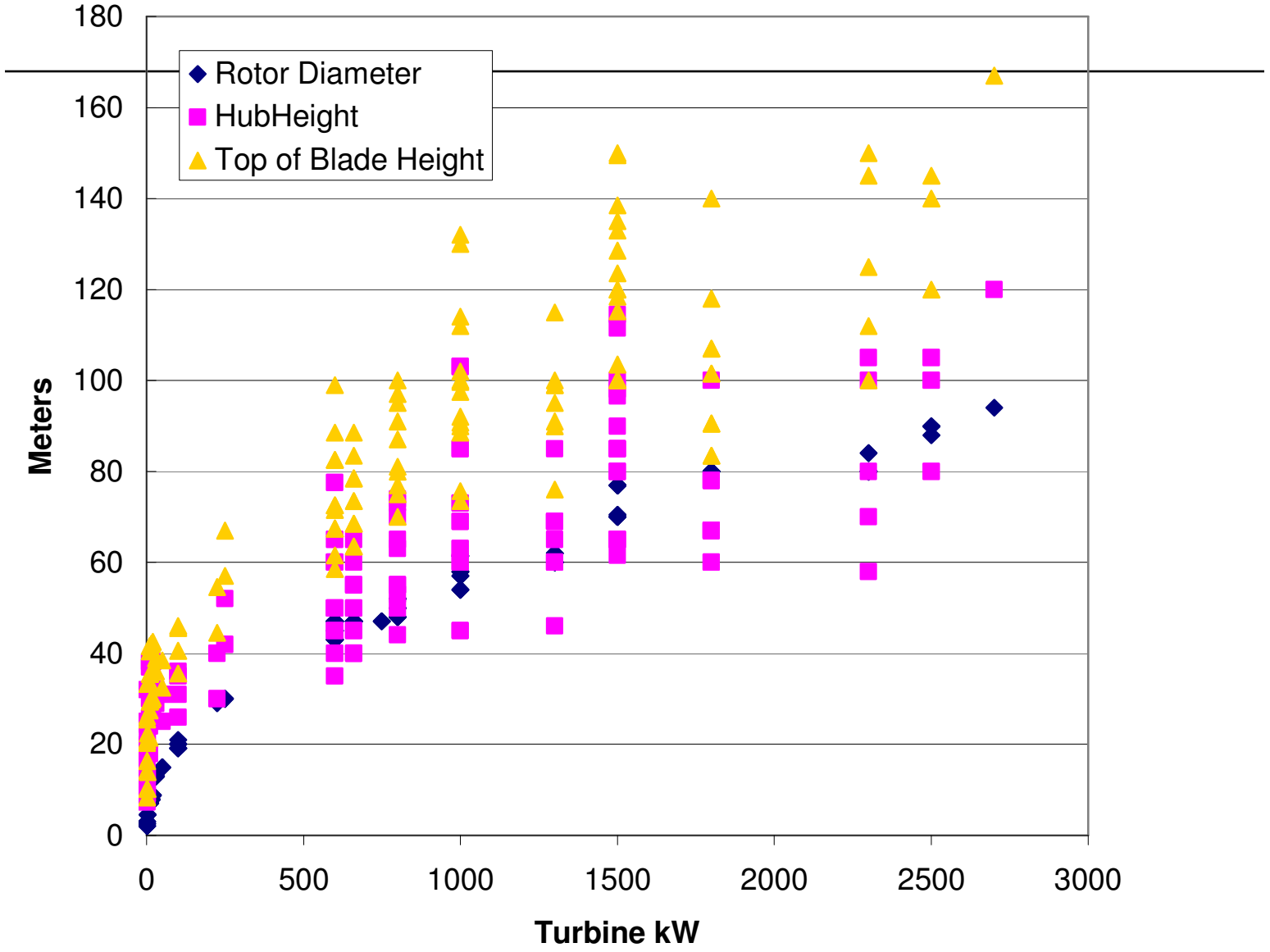
Turbine & Tower Costs

- Community Outreach
- Preliminary (FS; Met tower)
- Permitting
- Purchase Price
- Shipping
- Installation
  - Engineering /interconnection study/ ancillary facilities
- Commissioning
- Warranty Extension / O&M
- Insurance
- Overhaul
- Financing
- Management

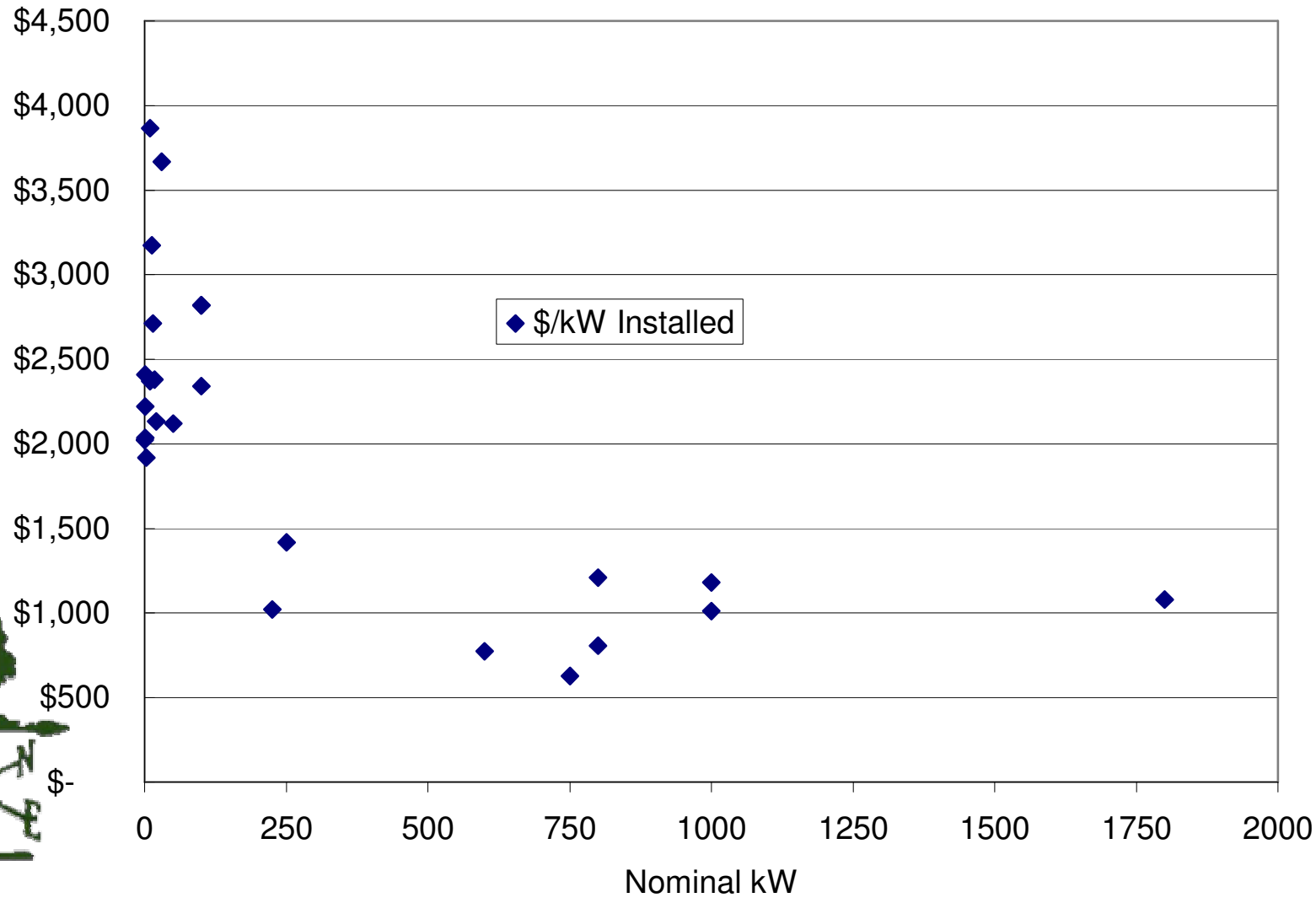
Turbine Power vs. Blade Length



Power (kW) vs. Height



Power (kW) vs. Cost / kW



Modeling Assumptions & Results

Modeling Assumptions - I

Site Attribute	Base Case Value
Avg. Anemometer Wind (m/s)	7.0
Anemometer. Height (m)	50
Turbulence Factor	0.1
Site Altitude (m)	50
Weibull K	2.5
Federal Production Tax Credit	Not Available
Months to Install from Project Start	12
Year of Project Start	2004
Dollars Per Euro	1.25
REC Price	0.0200 $/kWh
Average Wholesale Price	0.0400 $/kWh
Consumer Inflation	2%
Energy Inflation	2%
O&M Inflation	2%
Down Payment Percent	100%
Depreciation Method	MACRS
Project Development Fee	10%
MTC Buydown	$0

Prototypical Customer / NSTAR Rate Class Definitions

- R1 – Residential
- R3 – Residential Electric Heat
- G1 – Small Commercial
- G2 – Medium Commercial
- G3 – Large Commercial

Modeling Assumption – II

Description	Rate Class / Load Profile Class	Annual Consumption kWh (Rounded)	Federal Tax Rate	State Tax Rate
Residential	R1	6,000	28%	5%
Residential Electric Heating	R3	11,000	28%	5%
Small Commercial	G1	26,000	28%	5%
Medium Commercial	G2	1,200,000	35%	6%
Large Commercial & Industrial	G3	6,000,000	35%	6%

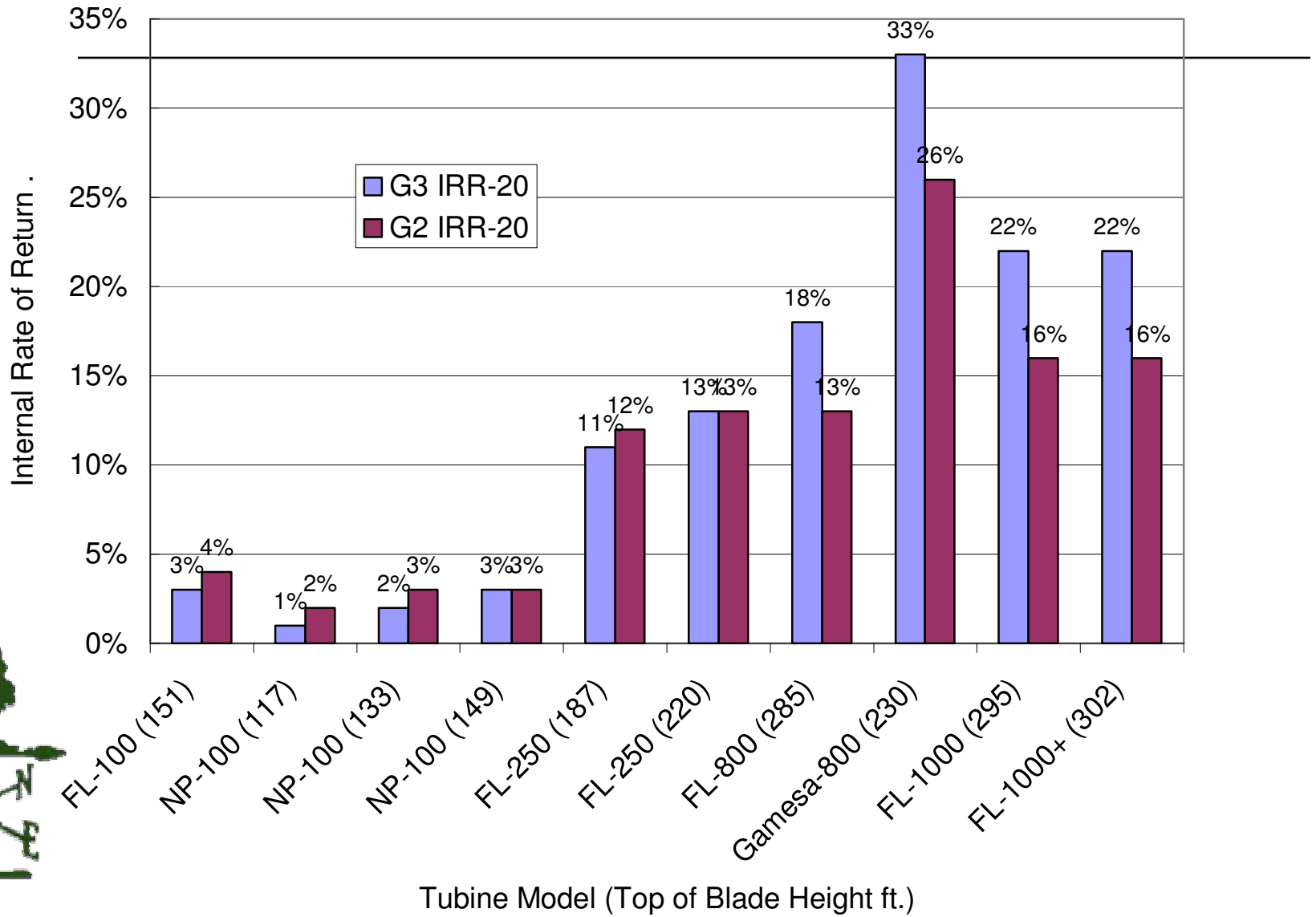
Modeling Assumptions - III

- Non-Generation Charges for 2006
  - Change and decrease over time

Rate Class	Cents / kWh
R1	4.1
R3	3.5
G1	4.1
G2	3.9
G3	3.0

- Generation Charges
  - 5.5 Cents / kWh

Modeling Results – G2 & G3



Results for Larger Customers (G2,G3)

- Internal Rate of Return (IRR) ranges from 3% to over 30%
- Associated years to positive cash-flow range from to 17 years to less than 3 years
- With smaller turbines G2 customers has better payback, with larger turbines G3 has better payback.
  - Explanation: When avoiding utility charges G2 customers have higher charges, but with larger turbines, G2 customers consume a smaller percent of turbine on-site, and thus only "receive" the lower average wholesale price for over-production.
- The best results are for the Gamesa_G52_800kW system, but this assumes a wind-farm size installation, not a single turbine.
  - Payback for other systems would also improve if we had been quoted a wind-farm sized installation.

Detailed Results – G2 (100-1000 kW)

Turbine	Tower / Top Blade Height (Feet)	IRR Over 20 Years	Years to Positive Cash Flow	Ann. kWh	$ / Installed kW
FL-100_100kW	108 / 151	3%	14.6	262,620	$2,893
Northern Power_NW100/19_100 kW	82 / 117	1%	17.0	159,517	$3,020
Northern Power_NW100/19_100 kW	98 / 133	2%	15.8	170,434	$3,050
Northern Power_NW100/19_100 kW	115 / 149	3%	14.8	180,210	$3,070
FL-250_250kW	131 / 187	11%	6.8	571,368	$1,642
FL-250_250kW	164 / 220	13%	6.3	610,894	$1,670
FL-800_800kW	197 / 285	18%	4.8	1,816,712	$1,328
Gamesa_G52_800kW	144 / 230	33%	2.7	1,867,217	$778
FL-1000_1000kW	197 / 295	22%	4.0	2,307,813	$1,101
FL-1000+_1000kW	197 / 302	22%	4.0	2,686,734	$1,261

Results for Smaller Customers (R1, R3, G1)

- Negative Net Present Value over 20 years for all turbine & tower combinations
  - Base case scenario results

Base Case Results – G1 Customer

Turbine	Top Blade Height (Feet)	Net Present Value 20 Years	Ann. kWh	$ / Installed kW
AOC_15/50_50kW	107	$(33,484)	124,018	$2,640
AOC_15/50_50kW	126	$(31,470)	133,877	$2,760
Northern Power_NW100/19_100kW	133	$(163,607)	170,434	$3,050
Northern Power_NW100/19_100kW	149	$(158,524)	180,210	$3,070
FL-30_30kW	128	$(125,051)	88,501	$4,233
FL-30_30kW	118	$(118,654)	86,074	$3,900
FL-30_30kW	128	$(129,104)	88,501	$4,400
FL-100_100kW	151	$(184,272)	262,620	$2,893
WTI_23-10_10kW	116	$(60,868)	20,838	$4,759
WTI_23-10_10kW	136	$(61,623)	22,155	$4,993
WTI_23-10_10kW	96	$(60,645)	19,307	$4,566
WTI_23-12.5_12.5kW	116	$(59,096)	26,047	$4,047
WTI_23-12.5_12.5kW	136	$(59,648)	27,694	$4,234
WTI_23-12.5_12.5kW	96	$(59,125)	24,134	$3,893

Wind Conclusion / Recommendations - Repeat

- A height restriction of 200 feet would be a *de facto* denial of economically feasible siting of wind turbines in all but the most unusual cases.
  - We recommend either 400 foot or no *a priori* height restriction on turbines in appropriate districts (e.g., commercial and industrial parks). A restriction of 200 feet height is most likely appropriate for residential zones.

Discussion Topics

- The effect of different height restrictions
- The potential for mitigation of visual impact through conservation or scenic area land banking
  - The higher a wind turbine, the more economically efficient, the greater the ability for financial set-aside for mitigation (e.g., tax the rich)
- Provide method for public education associated with wind turbine development
- Provide design competition for wind turbine color scheme

Contact Information

- Tom Michelman
  Boreal Renewable Energy Development
  978-580-6190
  tmichelman@boreal-renewable.com

- Bob Shatten
  Boreal Renewable Energy Development
  781-643-9772
  bshatten@boreal-renewable.com

- Dr. Adam Serchuk
  Serchuk Associates
  608-249-6295
  aserchuk@aol.com